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The development of electric herbal pad treatment for delayed onset muscle soreness after exercise training

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Abstract

Introduction. Intense exercise causes muscle pain or delayed onset muscle soreness. The most common symptoms are decreased muscle strength, muscle tenderness, and swelling. These symptoms are limited to physical activity in daily life. Treatment for muscle soreness after exercise is essential and easy to administer for example by applying superficial heat. The herbal compress is a traditional treatment in Thailand that has been used for relieving pain. Aim of Study. This study was to develop and determine the effect of an electric herbal hot compress pad on perceived muscle soreness sensation, muscle strength, range of motion after intense exercise induced muscle soreness. Material and Methods. There were 24 participants, aged 18-24 years old. The participants randomly received: (i) an herbal hot compress ball; or (ii) an electric herbal hot compress pad. Both groups received the respective treatments 24, 48, and 72 h after exercise for 40 min once a day. Muscle soreness was induced by Winged cycling using weight of 0.076 kg for 30 min. The perceived muscle soreness, muscle strength, and range of motion were measured immediately at the baseline, after intense exercise, and after treatment at 24, 48, and 72 h. Results. The results showed that all the variables were increased compared to baseline measurements after 30-min intense exercise. This indicates muscle damage. Furthermore, they showed that muscle soreness sensations decreased 72 h after treatment, with slight changes in muscle strength and range of motion after treatment. However, in the immediate application of heat in both groups there were no significantly different changes. Conclusions. This pilot study indicated that pain relief efficacy with the use of the electric herbal compress pad for delayed onset muscle soreness was not different from that of an herbal compress ball. However, a large long-term follow-up study on the therapy is needed.

KEYWORDS: electric herbal hot pad, Thai herb.

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Introduction

Intense exercise, particularly eccentric exercise, which exceeds your original performance or beyond what you previously performed, can cause delayed onset muscle soreness [3, 9]. It is a condition that requires a break from using muscle. The common symptoms include decreased strength, pain, muscle tenderness, stiffness, and swelling [16, 19, 27]. These symptoms are limited in physical activity, causing effects on various body systems, such as the musculoskeletal system. However, the severity of muscle pain depends on the intensity and duration of exercise [4, 5, 8, 26].

Muscular pain or muscle soreness after exercise is caused by morphological changes inside muscle fibers. The damage affects sarcomeres, causing an inflammatory response process by secreting prostaglandin E_2, in response to the inflammatory process causing pain, swelling, redness, the heat of the tissues, and inflammatory substances secreted by white blood cells (leukotriene synthesis) [14]. In the excitation-contraction interaction mechanism of the muscles, the onset of muscle discomfort occurs 8-12 h after activity, peaking 24-72 h after exercise. The pain gradually subsides in 5-7 days

[18]. According to the study of Eston et al. [7], muscle soreness after the downhill run causes muscle loss of strength and an increased level of the enzyme creatine kinase. Muscle pain after exercise is the leading cause of reduced muscle strength and angle of motion. Increased pain and inflammation of the muscles inhibit muscle recovery, which is the main reason for the reduction in exercise performance or athletic training, also having mental and psychological effects [2, 17, 25].

Treatment for muscle soreness after exercise is essential and may be administered e.g. by applying superficial heat, which requires the practice of 20-30 min per session. When a herbal compress (herbal ball) is applied, the heat and scent of the essential oils from the herbal compress help relieve muscle ache and tension [23]. Thailand has traditionally used herbs in the treatment or care of people's health using herbal compress ball products. The herbal compress ball is a cloth wrapped in herbs that has properties helping reduce muscle pain. The effects of using herbal hot compress balls include increased skin temperature and heart rate, drop in blood pressure because they can effectively transfer heat to the treated skin area, but they require steaming for 20 min before use [10, 21]. Lehmann et al. stated that the muscle temperature should be 40 °C to increase tissue temperature, blood circulation in the skin, and the body's metabolic rate [11]. However, local heat therapy relieves muscle fatigue during exercise, increases flexibility, and inhibits muscle pain [20, 22]. It involves herbal extracts with anti-inflammatory effects and the aromatic scent to help induce relaxation, such as carotenoids and polyphenols. Herbal extracts have a stimulating effect on the central nervous system through the stimulation of the hormones catecholamines. They increase alertness and decrease reaction time to reduce oxidative stress caused by exercise in athletes. The herbal hot compress ball has the advantages of increasing the tissue temperature and blood circulation, applying herbal extracts with pain-relieving effects, which better penetrate skin tissue into the bloodstream, carrying protein nutrients and oxygen into the injured cells and muscle tissue for faster healing, by reducing pain and inflammation, creatine kinase and prostaglandin E_2 in the blood. The heat causes an increase in the elasticity of the collagen tissue and the motion angle [12]. Steam in the hot compress ball for 20-30 min allows the medicines or essential oils to spread into the treatment area. In addition, constant pressing of the massage transfers heat to the untreated skin; however, the limitation of the use of herbal hot compress ball is that it cannot penetrate the skin. Therefore, the researchers aimed to develop the electric herbal hot compress pad treatment of delayed onset muscle soreness after exercise.

Material and Methods

Participants

Twenty-four university students participated in this study and signed an informed consent document approved by the Ethics Committee in Human Research, Mahasarakham University. The certification number was 038-019/2564. The participants were 18-24 years old. Inclusion criteria included being healthy, aged 18-24 years, exercising on an irregular basis max. three times a week, having no muscle injuries before joining the study, and having a normal body mass index (18.5-24.9 kg/m^2). The exclusion criteria included having no muscle soreness after exercise, unwillingness to participate in the study, and lack of attendance.

Study design

This study was controlled trial human experimental research. It was designed to develop and determine the effect of the electric herbal hot compress pad on perceived muscle soreness sensation, muscle strength, and range of motion after intense exercise. Muscle soreness of knee extensors was stimulated by indoor cycling using a weight of 0.076 kg for 30 min. Participants were determined all outcomes and received either treatment for 40 min. After treatments, perceived muscle soreness, muscle strength, and range of motion were measured at the baseline, at 30 min, 24, 48, and 72 h. The perceived muscle soreness, muscle strength, and range of motion were measured at the baseline, at 30 min, 24, 48, and 72 h after intense exercise.

Treatment procedures

The participants were randomly assigned to two groups of the same size, i.e. 12 participants each. Participants with eligibility criteria were randomized by drawing lots into two treatment groups: the herbal compress ball group and the electric herbal compress pad group. Participants received treatment for 40 min after intense exercise.

Herbal compress ball group

Participants in this group received an application of a herbal compress ball on both front thighs (Figure 1). Each herbal compress ball weighed 231 g and contained dried herbs including Zingiber cassumunar Roxb (100 g), Curcuma longa L. (50 g), Citrus hysteric D.C (36 g), Cymbopogon nardus (20 g), Dryobalanops aromatica Gaertn. (10 g), Cinnamomum camphora J.Presl (10 g),

and Sodium chloride (5 g). However, before being used in the treatment the herbal balls were steamed for 20 min. Afterward, the ball was wrapped in a towel to protect the participants' skin from being burnt due to excessive heat, and then the herbal ball was gently pressed and rolled on the treated areas for approximately 15 sec for each area. In this study, the herbal balls were used for three treatment visits before being replaced with the new balls when the next round of treatment started.

Figure 1. Treatment with the herbal compress ball

Electric herbal compress pad group

Participants in this group received the treatment of an electric herbal hot pad on both front thighs (Figure 2). The electric herbal hot compress pad consisted of two parts: an electrical device consisting of a temperature setting device with a temperature setting of 0-100 °C and a heat-generating device with a width of 10 cm by 12 cm in length. It was light and flexible with good heat transfer properties. The material used was laminated silicone fused with a rubber sheet. It transmitted heat and high pressure on both sides of the coil embedded inside the silicone. It could withstand the heat of 200 °C and the AC voltage of 12 V with no harm to the body. The size of the bag was 10 cm in width by 12 cm, containing herbal medicines. Inside the bag there was an herbal gel pad that had properties to relieve muscle pain. The herbal gel pad contained Plai oil (15 g), Bergamot oil (5 g), Ginger oil (5 g), salt (5 g), Carbopol 934 (5 g), Cremophor RH 40 (0.5 g), and Triethanolamine (0.5 g). The treatment temperature was 40-45 °C.

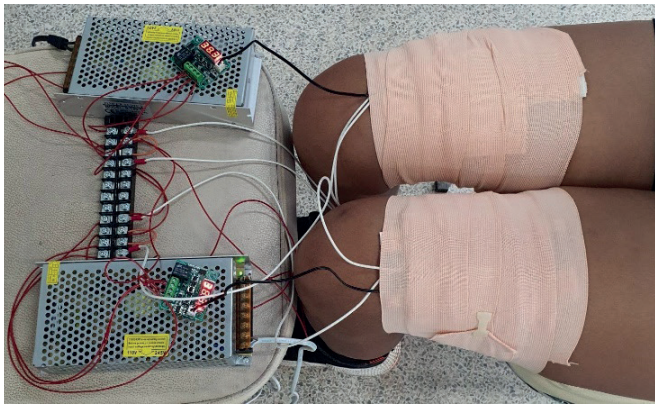

Figure 2. Treatment with the electric herbal compress pad

Exercise induced delayed onset muscle soreness

Delayed onset muscle soreness was induced in all the participants by standardized repetitive quadriceps muscle exercise using indoor cycling with a weight of 0.076 kg/body weight. The test required maximum effort for 30 min. Participants received instructions on the test. Weights were loaded onto the pan and suspended so that participants could begin pedaling with only the resistance of the flywheel; they were instructed to increase pedal cadence to 60-65 rpm during countdown and maintain this cadence until the signal to begin pedaling maximally was given. At "Go" the weight pan was lowered, and the participants began to pedal maximally against the resistance. Verbal encouragement was given to participants throughout the test to ensure maximal effort. The participants spun up to 100^{+} rpm on the "Go" signal. They received a final countdown near the end of the test. The weight pan was lifted to allow the participants to pedal without additional resistance. Participants were directed to the warm-up bike for 5 min to allow recovery.

Measurement

The perceived muscle soreness, muscle strength, and range of motion were measured immediately at the baseline, after intense exercise, after treatment, at 24 h, 48 h, and 72 h.

Perceived muscle soreness sensation

Perceived muscle soreness sensation was assessed on a numeric rating scale for pain (used because of its simplicity). The numeric rating scale consists of a horizontal bar marked with whole numbers from 0 to 10, with 0 being no pain and 10 being the worst pain. The participants were evaluated while flexing and extending the knee joint. Then they were asked to rate their pain level on the scale. The number of pain levels was recorded during the session. The pain was measured before the induction of muscle soreness at 24, 48, and 72 h subsequently. Participants rated their pain at the exact time when the measurement was taken, rather than as an average period of over 24 h.

Muscle strength

Participants' muscle strength was evaluated for their dominant quadriceps using leg dynamometry. The participants stood on the foot of the machine, bent their

knees at 90°. Both hands held the puller in a prone position, and then arranged the cable accordingly. The participant exerted a full leg stretch and held it for 10-15 sec. The unit of measure in kilograms and the results were divided depending on the body weight. The average of the two closest trials was recorded. Muscle strength was measured immediately before exercise and then again at the same time after 30 min of intense exercise, then measured again at 24, 48, and 72 h after treatment.

Range of motion

The research assistant used a goniometer to measure the degree of knee motion in a supine position from full extension to full knee flexion. The knee joint angle was between the lateral epicondyle of the femur, lateral malleolus of the fibula, and greater trochanter. The goniometer was placed with the goniometer pivot point upright the epicondyle of the femur, the stationary arm being positioned between the greater trochanter and middle of the femur, and the other between the femur. The moving arm was between the lateral malleolus and the middle of the fibular bone. The range of motion of the tested knee joint was measured to evaluate the degree of joint stiffness from muscle soreness.

Data analysis

The study results are presented by descriptive statistics including means, standard deviation, with statistical significance set at $p < 0.05$. They were used to compare the values of age, body mass, height, body mass index, heart rate, systolic and diastolic blood pressure at the baseline, and an independent sample t-test was also used. Overall effects and differences in perceived muscle soreness sensation, muscle strength, and range of motion between the two groups during the baseline and treatment periods were analyzed using two-way repeated-measures ANOVA and Tukey's test. The statistical analysis was conducted using the IBM SPSS statistics package (version 27.0).

Results

The physical characteristics of the participant groups are presented in Table 1 (n = 24; 12 male, and 12 female). There were no significant differences in all the variables found between the two groups in the treatment. There were no participants who dropped out of this study.

Response symptoms of muscle damage

An indirect symptom response indicating muscle damage after intense exercise includes e.g. the perceived muscle soreness sensation, muscle strength, range of motion as shown in Table 2. The intense exercise protocol was successful in producing perceived muscle soreness sensation. In the within-group analysis, the mean values of perceived muscle soreness sensation showed a significant increase ($p < 0.05$). However, after intense exercise in both groups muscle strength, and range of motion in all the groups were not significantly improved compared with their baselines.

Table 1. Baseline characteristics of participants

Characteristics	Treatment groups		p
	Herbal compress ball	Electric herbal compress pad	
n (male : female)	12 (6 : 6)	12 (6 : 6)	
Age (y)	19.33 ± 0.49	19.08 ± 0.65	0.31
Body weight (kg)	61.42 ± 11.62	64.83 ± 13.43	0.51
Height (cm)	165.08 ± 7.09	167.75 ± 10.67	0.48
BMI (kg/m^2)	21.94 ± 2.45	22.85 ± 2.71	0.40
HR (bpm)	76.08 ± 7.96	80.83 ± 14.07	0.32
Systolic (mmHg)	115.83 ± 9.09	117.17 ± 8.10	0.71
Diastolic (mmHg)	70.67 ± 7.88	73.58 ± 9.91	0.43

Note: There were no significant differences between both groups (all $p < 0.05$).

Treatment study

In the within-group analysis the mean values of perceived muscle soreness sensation showed a significant increase at the following periods ($p < 0.05$), after 30-min intense exercise, at 24, 48, and 72 h after treatment. The perceived muscle soreness sensation was greater in 48 h and decreased slowly after 72 h after treatment in both groups. There was no difference in muscle strength and range of motion in both groups after intense exercise and 24, 48, and 72 h after treatment compared to after 30 min. The muscle strength decreased within 48 h and gradually improved at 72 h after treatment. The slight changes in the range of motion were observed throughout the experiment. However, 72 h after treatment a greater range of motion was observed in the herbal hot compress ball group compared to the electric herbal hot compress pad group. Statistical tests showed that there was no significant difference in perceived muscle soreness sensation, muscle strength, and range of motion between the treatment groups (Table 2).

Table 2. Perceived muscle soreness, muscle strength, and range of motion of the two groups at baseline, after intense exercise, and after treatment

Groups	Baseline	After 30-min intense exercise	After treatment (hours)			p
			24	48	72	
Herbal compress ball						
Perceived muscle soreness sensation	0.00 ± 0.00	1.67 ± 0.78	5.17 ± 0.72	7.25 ± 0.87	5.17 ± 0.84	0.00*
Muscle strength	1.43 ± 0.27	1.63 ± 0.29	1.57 ± 0.34	1.38 ± 0.18	1.68 ± 0.32	0.10
Range of motion	130.33 ± 8.31	127.08 ± 8.94	127.00 ± 7.58	127.42 ± 7.48	131.00 ± 7.42	0.37
Electric herbal compress pad						
Perceived muscle soreness sensation	0.00 ± 0.00	1.92 ± 1.00	5.75 ± 0.75	6.75 ± 0.75	5.00 ± 0.74	0.00*
Muscle strength	1.43 ± 0.24	1.70 ± 0.29	1.60 ± 0.30	1.51 ± 0.34	1.79 ± 0.43	0.70
Range of motion	129.25 ± 6.20	130.50 ± 5.54	131.42 ± 3.92	132.42 ± 5.89	129.33 ± 5.82	0.58

* significant difference compared to baseline, after 30-min intense exercise, and after treatment ($p < 0.05$)

Discussion

This study shows that vigorous exercise causes delayed onset muscle soreness by significantly increasing the perceived muscle soreness sensation compared to the baseline in each group. The treatment of delayed onset muscle soreness with a herbal hot compress ball and an electric herbal compress pad lasted 40 min. Effects after compress application at 24, 48, and 72 h after intense exercise showed that there was no statistically significant difference at the 0.05 level due to the following factors; 1) The effects of heat on the nervous system and muscles reduce pain and inflammation, since the prolonged use of heat increases the temperature inside the tissue and affected the expansion of blood vessels, providing nutrients and oxygen into the cells. As substances and wastes were eliminated from the cells this led to a reduction in pain levels. Nadler et al. [20] found that an increase in body tissue temperature leads to blood circulation increasing in the skin, resulting in fluid movement in the body's tissues and increasing the metabolic rate of the body. Topical heat therapy improved flexibility and suppressed muscle pain. The increased heat expanded blood vessels, promoted blood flow, and released residual pain-causing substances. It resulted in increased cellular metabolism and enzyme activity. In addition, the heat was a stimulant of pain. According to Melzack and Wall's gate control theory, heat increases the pain threshold and reduces muscle spasms [1]. The heat from the herbal hot compress ball and the electric herbal hot compress pad stimulated large nerves to send signals to Substantia Gelatinosa (S.G.) and inhibited the conduction of nerve signals sent to the forwarding cells. Therefore, no nerve signals were sent to the brain, resulting in decreased muscle pain. According to the gate control theory, the detection of pain and pain control is executed by nerve signals, stimulated by different parts of the body, going through large and small nerve fibers. The nerve signals that pass through the two nerve fibers enter the spinal cord through the dorsal gate (Dorsal Horn) and then split in two ways. One part is forwarded to the Transmission Cell or T to carry the signal forward to the brain, and another part was to S.G., a tight group of neurons in the spinal cord where large and small nerve fibers meet. There is also an inhibitor neuron for receiving nerve signals that pass through the spinal cord, by secreting neurotransmitters to the forward cells. The large nerve fibers have more nerve signal power than the small ones that simulate S.G., causing no nerve signal to be sent to the transmission cells. Therefore, no further nerve signal is sent to the brain, resulting in the situation called "The door will close," and pain will not occur. However, if there is an increase in the neurotransmitter power in the tiny nerve fibers, it will cause the inhibition of S.G. as "The door will open." The nerve signals that pass through the gate to the cells to the brain cause the perception of pain. The nerve signals pass through the door to the cell, and then to the brain, causing the perception of pain. The nerve signals controlling the pain mechanism of the spinal cord are transmitted to the brain and the body's motion system. The application of a herbal hot compress and an electric herbal hot compress pad created superficial heat applied to the area to reduce pain, based on conduction and convection, in which the

heat source contacted with the treated area directly and the heat penetrated the dermis layer. As a result, heat reduced pain and muscle tension, increased the rate of blood circulation, caused the expansion of arteries and capillaries, reducing inflammation and swelling, and reducing symptoms of joint stiffness.

2) The active substances in the herbal hot compress and electric herbal hot compress pad have anti-inflammatory effects. Cassumunarins A, B, and C are compounds in the group of Complex Curcuminoids that have anti-inflammatory activity. In addition, Plai essential oils contain terpenoid groups such as α-pinene, sabinene, α-terpinene, terpinen-4-ol and phenylbutanoid substances such as (E) -1- (3,4-dimethoxyphenyl) butadiene (DMPBD), (E) -4 (3'-4'-dimethylphenyl) but-3-en-2-ol [24]. Previous studies revealed that various phytochemical extracts from Plai can reduce pain and inflammation. The heat caused the essence in the herbal hot compress ball and the electric herbal hot compress pad to evaporate from the herbal matter, thus it could well penetrate the skin because under the skin there is a fat layer, allowing easy penetration of important substances from Plai. For 20-60 min of therapy vital substances from Plai penetrate the circulatory system [6]. The heat source from the used herbal hot compress ball and electric herbal hot compress pad increased the temperature in the tissue area and blood circulation. It enhanced the penetration of substances from herbs with pain-relieving propertiesthrough the skin tissue into the bloodstream. With the introduction of protein nutrients, oxygen enters the injured area cells for faster healing of muscle tissue, reducing pain, soreness and inflammation, decreasing the levels of creatine kinase and prostaglandin E_2 in the bloodstream. Moreover, the heat also changed the elastic properties of collagen tissue and increased the angle of motion [1, 12]. The administration of a finished product containing 14% of essential oils from Plai rhizomes healed ankle injuries in male athletes by reducing swelling and pain, so that they could move their ankles downwards more [13, 15]. However, eccentric contraction exercises result in such high levels of muscle stiffness that tearing of the muscle fibers and connective tissue in the sarcolemma leads to the proliferation of calcium and enzymes such as myoglobin and cytosolic out of the cells, causing muscle strength to decline 24 h after exercise, while the amount of neutrophils and histamine increased due to the inflammatory process. After 48 h of exercise, the amount of macrophages was maximized, while the level of PGE_2, a stimulant for pain receptors, increased in the bloodstream [4, 5]. Using a herbal hot compress ball and an electric herbal compress pad provided superficial heat that was applied to treat the muscle soreness. When the heat source directly contacted the treated area, it carried the vital substances contained in Plai herb to penetrate the skin to the dermis layer, the circulatory system, and the lymphatic system. Therefore, the muscle area treated with a herbal hot compress ball and an electric herbal hot compress pad was affected by the active substances in Plai herb that had no significantly different properties to reduce pain and inflammation. However, for the treatment of muscular pain after exercise a product should provide constant heat for the herbal compress ball, and the time of use should be longer. In this way sore muscle treatment after exercise would be more effective according to the individual needs. In addition, the area treated using an electric herbal heat compress pad was heated throughout the treatment period and received the essential substances in the herbs evenly, unlike using an herbal hot compress ball that needed steaming to provide heat. After 20 min of use, the treatment was inconsistent and time consuming. Some limitations should be mentioned concerning this study. Further studies should be conducted with longer study periods. In addition, post-treatment follow-up is required to evaluate the carryover effect produced.

Conclusions

In this small study, these investigations reveal that superficial heat (using a herbal hot compress ball and an electric herbal hot compress pad) provided some significant benefits in the reduction of muscle soreness sensation and improved muscle strength following intense exercise. However, an electric herbal hot compress pad has the advantage of being able to distribute heat more evenly than the herbal compress ball. The use of the herbal compress ball required lifting to change the compress position, which resulted in uneven heat contribution. In summary, in the treatment of muscle soreness after exercise both methods help relieve pain. The herbal hot compress can increase the muscle tissue temperature and blood circulation, which provides protein nutrients. Oxygen enters the injured cells and muscle tissue for faster healing. This reduces pain and inflammation, reduces plasma creatine kinase and prostaglandin E_2 in the blood. Heat causes changes in the elasticity of collagen tissue and increases the angle of motion. This results in better performance in the activities of daily living.

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Conflict of Interest

The author declares no conflict of interest.

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